PhytoKeys 202: 45–52 (2022)
doi: 10.3897/phytokeys.202.80554
https://phytokeys.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
PhytoKeys
Launched to accelerate biodiversity research

Chrysanthemum dabieshanense, a new name for *Chrysanthemum vestitum* var. *latifolium* (Asteraceae, Anthemideae)

Zhixi Fu[1,2], Xiaofeng Liu[1], Aiguo Zhen[3], Xinxin Zhu[4], Kamil Konowalik[5], Yueping Ma[6], Pan Li[7]

1 *College of Life Sciences, Sichuan Normal University, Chengdu 610101 China* **2** *Sustainable Development Research Center of Resources and Environment of Western Sichuan, Sichuan Normal University, Chengdu 610101, China* **3** *Foresty Bureau of Yingshan County, Huanggang 421124 China* **4** *College of Life Sciences, Xinyang Normal University, Xinyang 464000, Henan, China* **5** *Department of Plant Biology, Institute of Environmental Biology, Wrocław University of Environmental and Life Sciences, Wrocław 5b, 51-631, Poland* **6** *College of Life and Health Sciences, Northeastern University, Shenyang 110004, China* **7** *College of Life Sciences, Zhejiang University, Hangzhou 310058 China*

Corresponding authors: Yueping Ma (mypluna@sina.com), Pan Li (panli_zju@126.com)

Academic editor: Alexander Sukhorukov | Received 14 January 2022 | Accepted 3 July 2022 | Published 21 July 2022

Citation: Fu Z, Liu X, Zhen A, Zhu X, Konowalik K, Ma Y, Li P (2022) *Chrysanthemum dabieshanense*, a new name for *Chrysanthemum vestitum* var. *latifolium* (Asteraceae, Anthemideae). PhytoKeys 202: 45–52. https://doi.org/10.3897/phytokeys.202.80554

Abstract

Recent phylogenetic analyses have revealed that *Chrysanthemum vestitum* var. *latifolium* and *C. vestitum* var. *vestitum* were placed in different clades based on their chloroplast genomes and nuclear LFAFY gene sequences. Accordingly, based on previous morphological analysis, molecular phylogenetic results, field-work, and herbarium studies, *Chrysanthemum vestitum* var. *latifolium* should be raised to the species level. Considering the condition of the material found and Articles 6.9, 6.11, 41.2, 58.1 of the International Code of Nomenclature for Algae, Fungi, and Plants (*Shenzhen Code*) that is currently in force, *Chrysanthemum dabieshanense* Z.X.Fu, A.G.Zhen, & Y.P.Ma, **nom. nov.** is proposed as the new name for *Chrysanthemum vestitum* var. *latifolium* J.Zhou & Jun Y.Chen. The detailed emended description, distribution map, insights into its habitat, and an updated comparative morphological study are presented in this study.

Keywords

Asteraceae, China, *Chrysanthemum* endemism, taxonomy

Copyright *Zhixi Fu et al.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Introduction

Chrysanthemum L. is a genus of the tribe Anthemideae that contains approximately 40 species. This genus is mainly distributed in temperate Asia (Oberprieler et al. 2007), with approximately 23 species in China (Shih et al. 2011; Meng et al. 2020). The genus is characterized by subshrubs or perennial herbs with pinnately or palmately divided alternate leaves, female ray florets, white or red apical appendages of anthers, and faintly 5–8-ribbed achenes (Shih et al. 2011). Furthermore, recent molecular phylogenetic studies have demonstrated that Chinese *Chrysanthemum* should be divided into two groups: the *Chrysanthemum zawadskii* group, which is distributed in northern China and has erect stems and large capitula with white or purple ray florets, and the *Chrysanthemum indicum* group, which is distributed from north to south China and has creeping stems and capitula with yellow or white ray florets (Liu et al. 2012; Li et al. 2014; Ma et al. 2020).

According to the phylogenetic study of chloroplast genomes and the nuclear *LFAFY* gene by Ma et al. (2020), *Chrysanthemum vestitum* var. *vestitum* from the Funiu Mountain in Henan Province and *C. vestitum* var. *latifolium* from the Tianzhu Mountain in Anhui Province represent two distinct clades. Morphologically, *C. vestitum* var. *latifolium* is not similar to other species of Clade I (Shih et al. 2011). Accordingly, based on the morphological and molecular results, we propose that the variety *Chrysanthemum vestitum* var. *latifolium* should be raised to the species level.

This evidence of phylogenetic results seems to be sufficient for a new taxonomic decision. This study aimed to describe one of the species of *Chrysanthemum* and investigate its phylogenetic affinities based on molecular and morphological data. Combined with previous morphological and field studies, we also provide a distribution map and information on the taxonomy of *Chrysanthemum dabieshanense*.

Materials and methods

We employed standard techniques for morphological studies of herbarium specimens and digital images of the most closely related species from the herbaria CSH, HIB, K, KUN, PE, WUK; acronyms follow Thiers (2022), including the holotype specimens of *Chrysanthemum vestitum* (Hemsl.) Stapf (Fig. 1A) (K, images seen). Dr Z.X. Fu visited the PE herbarium (Institute of Botany, Chinese Academy of Sciences) in June 2021 and compared and checked the holotype specimen of *Chrysanthemum vestitum* (Hemsl.) Stapf. var. *latifolium* J.Zhou et J.Y.Chen (East China Station Inst. Bot. 6935, Fig. 1B, PE). We also verified that morphological characteristics of voucher specimen MYP-20160826 (Fig 2, Ma et al. 2020, photo from Y.P. Ma) are identical to those of the type specimen of *C. vestitum* var. *latifolium*.

The morphological characteristics of *C. vestitum* var. *latifolium* and its related species were examined for comparative research based on measurements of herbarium

Figure 1. The images of the holotype of *Chrysanthemum vestitum* and *Chrysanthemum vestitum* (Hemsl.) Stapf. var. *latifolium* **A** the lectotype of *Chrysanthemum vestitum* (Hemsl.) Stapf. Image courtesy of the Royal Botanic Gardens, Kew (K). (Type: China. Hubei: Yichang city, "Ichang and immediate neighborhood", Sep 1886, *A. Henry 1115* lectotype, K000891712) **B** the holotype of *Chrysanthemum vestitum* (Hemsl.) Stapf. var. *latifolium* J.Zhou et J.Y.Chen. Image courtesy of the Herbarium PE, (Type: China, Anhui Province: Yuexi County, Baojia River, alt. 1500 m, 24 Sep 1953, *East China Station Inst. Bot. 6935* holotype, PE 00544099!).

specimens (Table 1), supplemented by photos of mature living plants collected from the field (photos from A.G. Zhen and X.X. Zhu). The localities were sorted according to county-level administrative divisions of the People's Republic of China.

Results and discussion

Zhou and Chen (2010) reported a new variety: *Chrysanthemum vestitum* (Hemsl.) Stapf. var. *latifolium* J.Zhou et J.Y.Chen from China (Fig. 1B). In their study, the holotype specimen of *Chrysanthemum vestitum* var. *latifolium* was collected from the Tianzhu Mountain (Anhui Province, Fig. 1B). The variety *Chrysanthemum vestitum* var. *latifolium* is mainly distributed on the western slopes of the Dabie Mountains, throughout the Anhui and Hubei provinces (Qi et al. 2021). It has long been treated as a variety of *Chrysanthemum vestitum* (Fig. 1A). Based on a recent study by Meng et al. (2020), principal component analysis of leaf length (L), leaf width (W), petiole length (P), and relative petiole length (B = P/L) between *C. vestitum* and *C. vestitum*

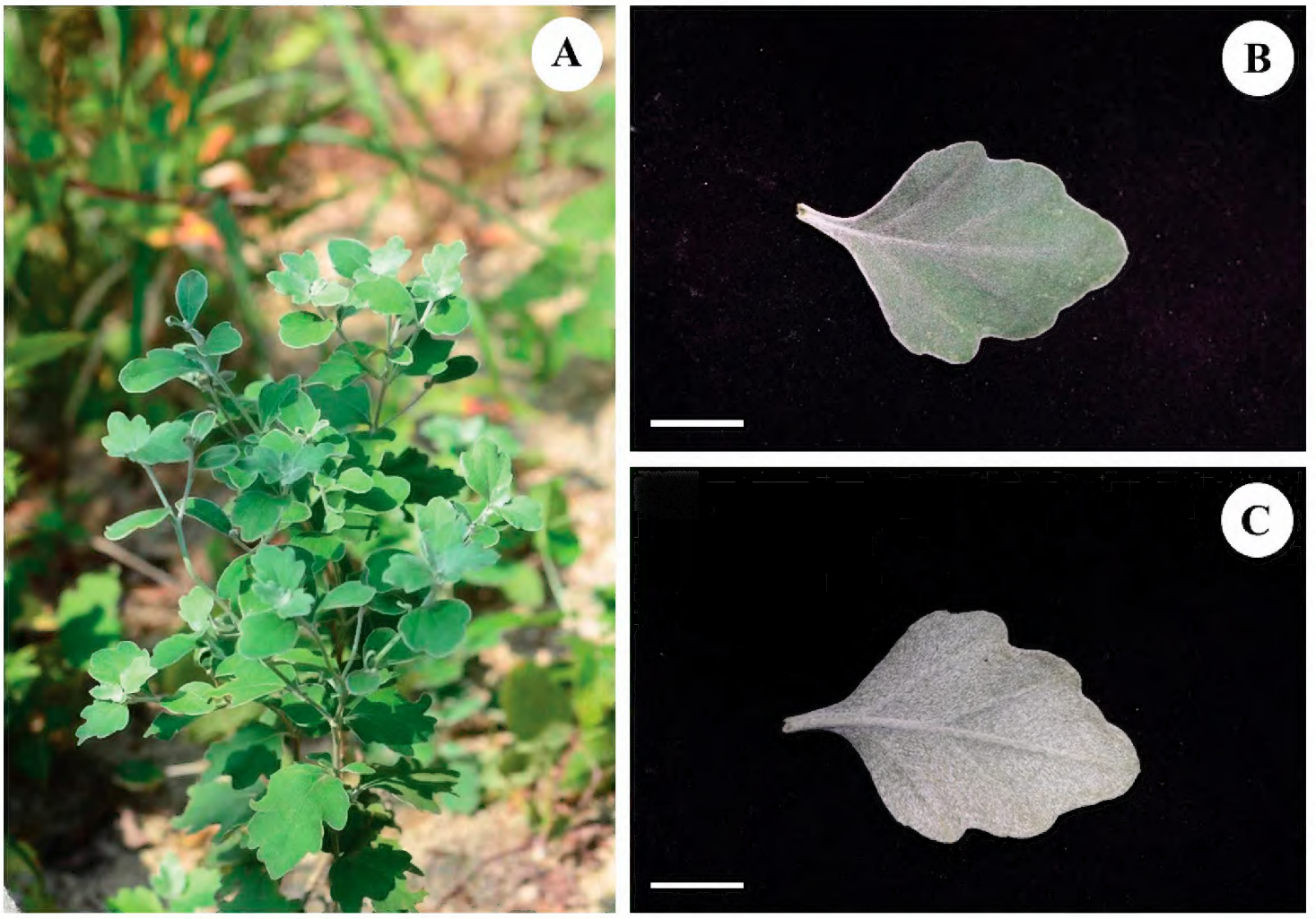

Figure 2. A plant of *Chrysanthemum vestitum* (Hemsl.) Stapf var. *latifolium* collected at Tianzhu Mountain, Dabieshan mountains (The voucher no. MYP-20160826, WUK, Ma et al. 2020) **A** plant growing in natural habitat **B** the adaxial side of leaf **C** the abaxial side of leaf. Scale bar: 2 cm (**B, C**). Photographed by Yue-ping Ma.

var. *latifolium* was conducted, and the two varieties of *C. vestitum* differed slightly. The difference between the new variety and the original species is that the new variety is less branched and has orbicular and ovoid leaves that are 4–7 cm long and 3–5 cm wide, and the diameter of its capitula is larger, reaching 4.5–5.0 cm (Table 1). The morphology of *C. vestitum* var. *latifolium* is distinct from other species in the same clade in terms of the leaf shape and length of capitula (Shih et al. 2011; Ma et al. 2020) (Table 1).

Based on a phylogenetic study of whole chloroplast genomes (Ma et al. 2020), two distinct clades were recognized in the genus *Chrysanthemum*. Clade I comprised *C. chanetii*, *C. indicum*, *C. lavandulifolium*, *C. nankingense*, *C. zawadskii*, *C. dichrum*, *C. mongolicum*, *C. oreastrum*, *C. glabriusculum*, *C. boreale*, *and C. vestitum* var. *latifolium* from Tianzhu Mountain in the Dabieshan Mountain area (the *Chrysanthemum zawadskii* group). Clade II consisted of *C. rhombifolium*, *C. indicum* var. *aromaticum*, *C. potentilloides*, *C. hypargyrum*, *C. argyrophyllum*, and *C. vestitum* var. *vestitum* (Fig. 3 A, C) (the *Chrysanthemum indicum* group). Based on the nuclear *LFAFY* gene, *Chrysanthemum vestitum* var. *latifolium* and *C. vestitum* var. *vestitum* were treated as two distinct species in different clades (Ma et al. 2020). Accordingly, based on the morphology and molecular results, we propose that the variety *Chrysanthemum vestitum* var. *latifolium* should be raised to the species level.

Table 1. Comparative measurements in *Chrysanthemum dabieshanense* (= *C. vestitum* var. *latifolium*) and its related species (based on Shih et al. 2011 and additional specimens at the herbaria visited).

	C.dabieshanense	***C. vestitum* var. *vestitum***	***C. mongolicum* (Clade I)**	***C. indicum* (Clade I)**	***C. zawadskii* (Clade I)**	***C.lavandulifolium* (Clade I)**
Leaf blades	orbicular or ovate-orbicular, 4–7 × 3–5 cm, obtusely 2- or 3-lobed	ovate, broadly ovate, oblong, 3.5–7 cm × 2–4 cm, margin repand-dentate	broadly ovate or elliptic 1–2 cm × 1.5–1.8 cm, bipinnatisect	ovate, long ovate, or elliptic-ovate,3–7 cm × 2–4m, bipinnatisect	ovate, broadly ovate, 1.4–4 ×1–3.5 cm, bipinnatisect	ovate, broadly ovate, elliptic-ovate, narrowly elliptic, 2–7 × 1.5–4.5 cm, bipinnatisect
Phyllaries	4 rows	4 rows	5 rows	5 rows	4 rows	5 rows
Capitula	4.5–5 cm in dia.	2–3 cm in diam.	3–4.5 cm in diam.	2.5–4 cm in diam.	1.5–4.5 cm in diam.	1–1.5 cm in diam.

Taxonomic treatment

***Chrysanthemum dabieshanense* Z.X.Fu, A.G.Zhen, & Y.P.Ma, nom. nov.**
urn:lsid:ipni.org:names:77302160-1

≡ *Chrysanthemum vestitum* var. *latifolium* J.Zhou & J.Y.Chen, Bull. Bot. Res. Harbin. 30: 649. 2010.

Note. According to International Code of Nomenclature for algae, fungi, and plants (ICN) Articles 6.9, 6.11, 41.2, and 58.1 (Turland et al. 2018), *Chrysanthemum dabieshanense* Z.X.Fu, A.G.Zhen, & Y.P.Ma, nom. nov. is proposed here as an explicit substitute for the legitimate name *Chrysanthemum vestitum* var. *latifolium*, because the epithet *latifolium* cannot be used for the present combination because of the existence of the name *Chrysanthemum latifolium* (DC.) Baksay, Ann. Hist. Nat. Mus. Natl. Hung. 8: 161, 1957 (online resource from https://www.tropicos.org/name/50268974). The specific epithet "*dabieshanense*" refers to the name of the Dabieshan (= Ta-pieh) mountain area, located at the border of the Anhui, Hubei, and Henan Provinces, where the species occurs. *Chrysanthemum dabieshanense* is endemic and restricted to the Dabieshan Mountain area (Hubei and Anhui provinces). Therefore, we accept *Chrysanthemum dabieshanense* as a replacement name for *Chrysanthemum vestitum* var. *latifolium*. A taxonomic treatment is presented.

Type. China. Anhui Prov. Yuexi County, Baojia River, shady slope at the top of the hill, alt. 1500 m, 24 Sep 1953, East China Station Inst. Bot. 6935 (holotype, PE 00544099!, isotype NAS 00486826 photo seen) (Fig. 1B)

Description. Perennial rhizomatous herbs, 60–100 cm tall. Stems sprawling, not much branched. Lower stem leaves withered at anthesis. Middle stem leaf blades orbicular or ovate-orbicular, 4–7 cm × 3–5 cm, grayish-green adaxially, grayish-white abaxially, margin above middle obtusely repand-dentate, distal stem leaves sessile or subsessile, capitula 3–10, 4.5–5 cm in diameter. Involucres cup-shaped; phyllaries in 4 rows, abaxially densely pubescent, scarious margin brown, outer phyllaries triangular or triangular-ovate, 3.5–4.5 mm, middle phyllaries lanceolate-ovate, ca. 6.5 mm, inner phyllaries obovate or oblanceolate-elliptic, 6–7 mm long. Ray floret lamina white, 1.2–2 cm long. Achenes ca. 1.5 mm long (Fig. 2, Fig. 3 B, D).

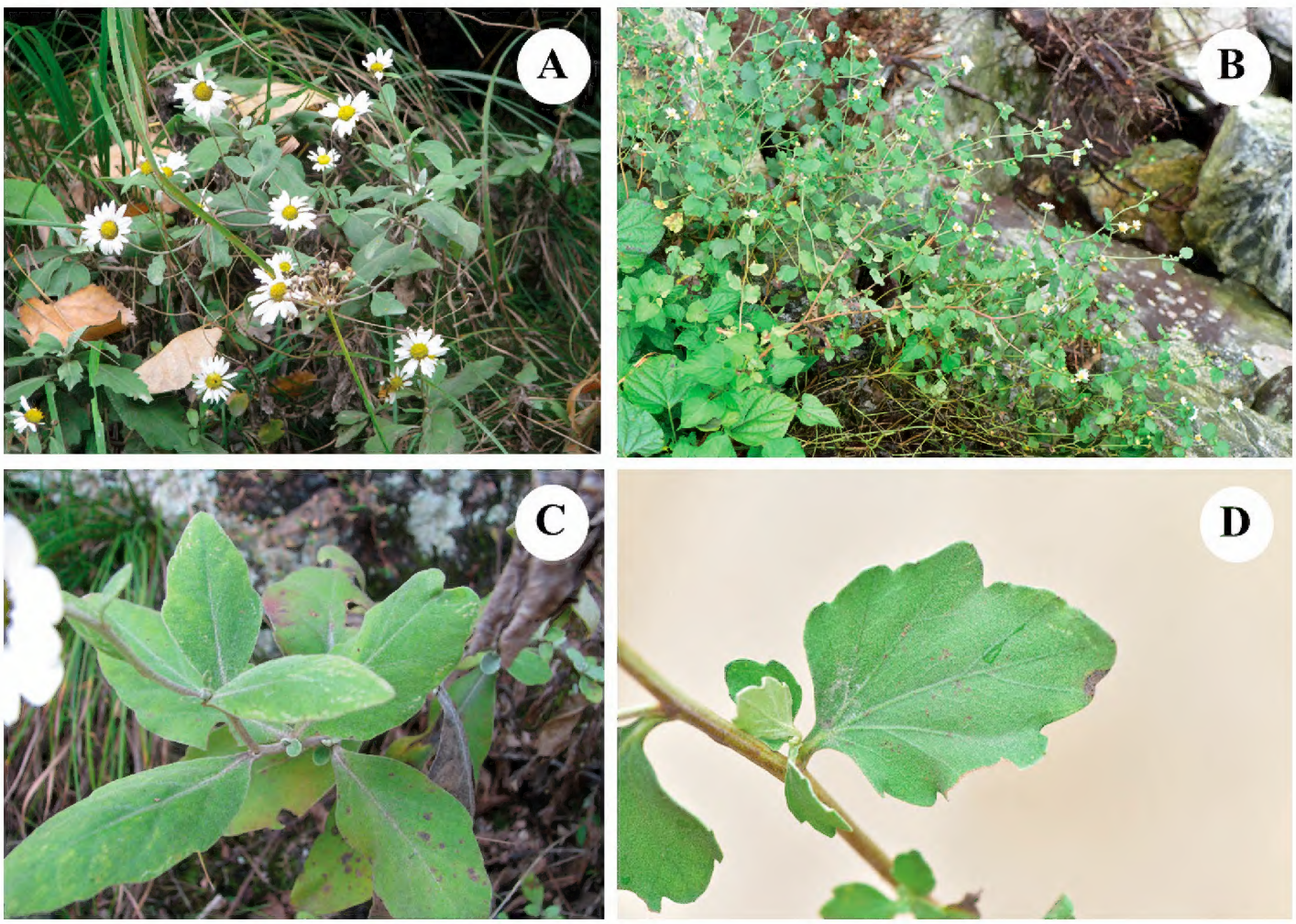

Figure 3. The images of *Chrysanthemum vestitum* and *Chrysanthemum dabieshanense* **A, B** plants growing in natural habitat **C, D** adaxial side of leaf (**A, C** *Chrysanthemum vestitum*, voucher *Z.X. Fu 610*, PE, Lushi county, Henan province, China, Photographs by Zhixi Fu). (**B, D** *Chrysanthemum dabieshanense*, voucher *X.X.Zhu 089* CSH, Yingshan county, Hubei province, China. Photographs by Xinxin Zhu).

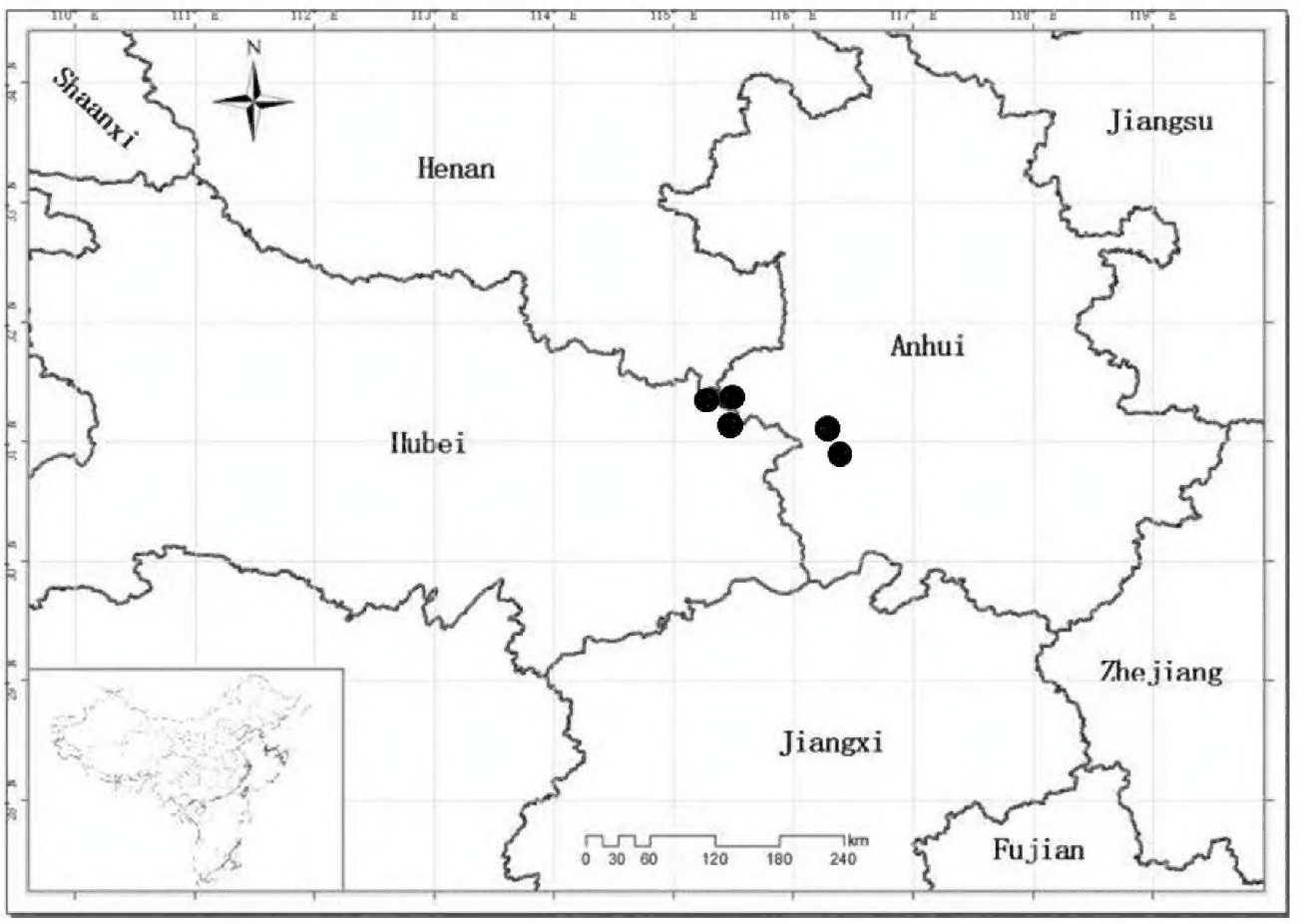

Figure 4. Distribution map of *Chrysanthemum dabieshanense* (black circles) in Anhui and Hubei provinces, China, based on the voucher specimen information.

Specimens examined. China – Anhui Prov. Jinzhai County, [without exact locality], *M.B. Deng & H.T. Wei 81350, 81196* (NAS); ibidem, *B. Chen CB07550* (CSH), Qianshan City, *S. J. Yang et al. 7193* (NAS), Y.P. Ma *MYP-20160826* (WUK); Hubei Prov. Yingshan County, Wujiashan Forest Farm, *X.X. Zhu 089* (KUN, CSH); Luotian County, Tiantangzai, *A.G. Zhen DBSYS708* (HIB); *X.X. Zhu 211858* (KUN).

Distribution and habitat. Endemic to the Dabieshan mountain area (Anhui and Hubei Provinces, China, Fig. 4). It grows on shaded slopes, hills, and streamsides, at alt. 800–1600 m.

Phenology. Flowering and fruiting are observed in October.

Chinese name. Da-Bie-Shan-Ju (大别山菊).

Acknowledgements

The authors thank curators and relevant staff of the CSH, HIB, K, KUN, PE, WUK herbaria who granted access to their collections and images. We also thank Dr. Caifei Zhang (Wuhan Botanical Garden, the Chinese Academy of Sciences), Dr. Guojin Zhang (Pennsylvania State University), Dr. Shuai Liao (East China Normal University) and Dr. Peiliang Liu (Northwest University), Associate Prof. Longfei Fu (Guangxi Institute of Botany, Guangxi Zhuang Autonomous Region and Chinese Academy of Sciences) for their critical comments and great help, Mr. Xingyong Cui (Beijing Forestry University) for drawing distribution map. We also thank the anonymous reviewers and editor for constructive criticism of the original manuscript. This study was financially supported by the National Natural Science Foundation of China (No. 32000158, 31872710, 31970225), the National Science & Technology Fundamental Resources Investigation Program of China (No. 2019FY101809, 2021XJKK0702) and the Foundation of Sustainable Development Research Center of Resources and Environment of Western Sichuan, Sichuan Normal University (No. 2020CXZYHJZX03).

Reference

Li J, Wan Q, Guo YP, Abbott RJ, Rao GY (2014) Should I stay or should I go: Biogeographic and evolutionary history of a polyploidy complex (*Chrysanthemum indicum* complex) in response to pleistocene climate change in China. The New Phytologist 201(3): 1031–1044. https://doi.org/10.1111/nph.12585

Liu PL, Wan Q, Guo YP, Yang J, Rao GY (2012) Phylogeny of the genus *Chrysanthemum* L.: Evidence from single-copy nuclear gene and chloroplast DNA sequences. PLoS ONE 7(11): e48970. https://doi.org/10.1371/journal.pone.0048970

Ma YP, Zhao L, Zhang WJ, Zhang YH, Xing X, Duan XX, Hu J, Harris AJ, Liu PL, Dai SL, Wen J (2020) Origins of cultivars of *Chrysanthemum* – Evidence from the chloroplast genome and nuclear LFY gene. Journal of Systematics and Evolution 58(6): 925–944. https://doi.org/10.1111/jse.12682

Meng SY, Wu L, Shen CZ (2020) *Chrysanthemum bizarre*, a new species of *Chrysanthemum* from Hunan, China. Phytotaxa 442: 215–224. https://doi.org/10.11646/phytotaxa.442.3.7

Oberprieler C, Vogt R, Watson LE (2007) *Chrysanthemum* L. In: Kadereit JW, Jeffrey C (Eds) The families and genera of vascular plants Vol. 8, Springer, Berlin, Heidelberg, 357.

Qi S, Twyford AD, Ding JY, Borrell JS, Ma YP, Wang N (2021) Natural interploidy hybridization among the key taxa involved in the origin of horticultural chrysanthemums. Journal of Systematics and Evolution jse.12810. https://doi.org/10.1111/jse.12810

Shih C, Christopher JH, Michael GG (2011) *Chrysanthemum*. In: Wu ZY, Raven PH, Hong DY (Eds) Flora of China. Beijing: Science Press; St. Louis: Missouri Botanical Garden Press, Vol. 20–21: 669–676.

Thiers B (2022) [continuously updated] Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. http://sweetgum.nybg.org/science/ih/ [accessed 17.1.2022]

Turland NJ, Wiersema JH, Barrie FR, Greuter W, Hawksworth DL, Herendeen PS, Knapp S, Kusber WH, Li DZ, Marhold K, May TW, McNeill J, Monro AM, Prado J, Price MJ, Smith GF [Eds] (2018) International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017. Regnum Vegetabile 159. Koeltz Botanical Books, Glashütten. https://doi.org/10.12705/Code.2018

Zhou J, Chen JY (2010) A new variety of the genus *Chrysanthemum* L. from China. Bulletin of Botanical Research 30(6): 649–650.